All bodies in the universe are attracted toward one another with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

For all the moments of a single hour, and even for all the moments in one day,

One of the earliest sensations to which a man is exposed... -- Charles Dickens

The Weight of Weight

Laws of Gravitation

Newton's law of universal gravitation states that the gravitational force between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. Mathematically, this is expressed as:

\[ F = G \frac{m_1 m_2}{r^2} \]

where:
- \( F \) is the gravitational force between the two objects,
- \( G \) is the gravitational constant,
- \( m_1 \) and \( m_2 \) are the masses of the two objects,
- \( r \) is the distance between the centers of the two objects.

This law explains why planets orbit the sun and why objects on the ground are pulled toward the center of the earth. The force of gravity is what keeps us on the ground and prevents us from flying into space.

Exercises

1. Calculate the gravitational force between two objects of masses 10 kg and 20 kg that are 1 meter apart. Use the value of \( G = 6.674 \times 10^{-11} \) m\(^3\)kg\(^{-1}\)s\(^{-2}\).

2. If the mass of the sun is approximately 2 \times 10^{30} \text{ kg}, the mass of the earth is approximately 6 \times 10^{24} \text{ kg}, and the distance between them is 1.5 \times 10^{11} \text{ m}, what is the gravitational force between the sun and the earth?

3. If the weight of an object is 100 pounds, what is its mass in kilograms? (Note: 1 pound = 0.453592 kg)

4. If an object falls from a height of 10 meters, what is the gravitational force acting on it? Assume the acceleration due to gravity is 9.8 m/s\(^2\).

5. If the distance between two objects is doubled, how does the gravitational force change?

Further Reading

- "Principia Mathematica" by Isaac Newton
- "The History of Astronomy" by R.T. Gregory
- "Gravitational Lensing and Cosmology" by John T. Ardila and Victor M. B. Lane
- "Newtonian Gravitational Theory and Its Application to Line Spectra" by D. J. Chelikowsky and M. J. Mehlhorn

References


Figures

- Figure 1: The gravitational force between two objects (Newton's law of universal gravitation).
- Figure 2: The orbit of a planet around the sun (Kepler's laws of planetary motion).
- Figure 3: The moon's orbit around the earth (gravitational forces between the earth and the moon).

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